TECHNICAL MANUAL

OPERATION, SERVICE AND REPAIR INSTRUCTIONS

5000 GALLON LIQUID OXYGEN/NITROGEN STORAGE TANK TYPE TMU-20/E

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FOREWORD/PREFACE

Purpose. This technical manual will provide the using activity with operation and service instructions for the Liquid Oxygen and Nitrogen Storage and Transfer Tank, Type TMU-20/E.

Scope. This manual will provide the using activity with applicable information required on the handling, storage, and hazards associated with the use of cryogenic equipment and products. Any corrections regarding this technical manual should be submitted in accordance with T.O. 00-5-1.

Throughout this manual the unit will primarily be called the Tank. It may also be called the Storage Tank. Tanks referenced but not covered by this manual will contain additional descriptions. Example: supply tank and receiving tank. Liquid nitrogen may be referred to as the product, or abbreviated as LIN in parts of this manual.

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SAFETY SUMMARY

The following are general safety precautions which are related to liquid nitrogen equipment. These are recommended precautions that personnel must understand and apply during many phases of operation and maintenance while using this equipment. Specific precautions will be included in the text for certain potentially hazardous operations in the form of a WARNING or CAUTION statement. The following information appears in the text of this publication and is presented here for emphasis.

QUALIFIED PERSONNEL

Only qualified personnel shall be authorized to operate and perform maintenance on this equipment.

PROTECTIVE EQUIPMENT

Personnel operating and performing maintenance on this equipment shall wear protective clothing and equipment as directed in T.O. 00-25-172 and applicable AFOSH standards.

BODILY CONTACT

Never allow liquid nitrogen or the piping on the equipment to contact the skin. The extremely low temperatures created by liquid nitrogen will immediately freeze the body area and result in severe frostbite.

EMERGENCY TREATMENT OF BODILY CONTACT

In the event of bodily contact with liquid nitrogen or the Tank piping, remove the victim from the exposure immediately. Do not attempt to re-warm any bodily parts as this should be accomplished by proper medical personnel. Transport the patient to an emergency room of a hospital or clinic as soon as possible. Keep the patient dry and warm enroute to the emergency room. Upon arrival identify the injury as exposure to liquid nitrogen.

UNAUTHORIZED CONTAINERS

Never put liquid nitrogen in any container without proper safety devices (e.g. thermos bottle). When heated, liquid nitrogen will expand rapidly and build pressures to extremely high levels. The results of pressure buildup without safety devices may result in an explosion.

SAFETY SUMMARY-CONTINUED

KEEP AWAY FROM ABSORBENT MATERIALS

Liquid oxygen must be kept away from absorbent materials such as rags, wood, paper, and clothing. These materials may trap the oxygen gas and later be ignited by nay source of spark or flame.

KEEP AWAY FROM HYDROCARBONS

Liquid oxygen is not compatible with hydrocarbons. Forms of hydrocarbon are oils, greases, gasoline, tar, and asphalt. Liquid oxygen in contact with hydrocarbons present a severe explosive hazard. The equipment, its components, and tools used in maintenance must be kept free of hydrocarbons.

SMOKING

Do not smoke or permit smoking within fifty (50) feet of Tanks in liquid oxygen service. Do not carry sources of flame in the vicinity of Tanks in liquid oxygen service. Use caution in smoking immediately after being exposed to liquid oxygen vapors as these vapors may be still trapped in clothing.

VENTILATION

Adequate ventilation must be provided for personnel for Tank functions such as transfer operations, filling, draining, purging, painting, welding, brazing, and cleaning.

LIFTING

Equipment used in lifting and moving the Tank must be of sufficient rating to handle the weights involved.

PART CLEANNESS

All parts used in liquid oxygen service must be kept clean and free of hydrocarbons. Never use shop air to dry clean parts. Ultraviolet lights are used to check parts that have been cleaned. Overexopsure to ultraviolet light can result in conjunctivitis (inflammation of the inner eyelid and eyeball) and possible skin burns which could result in skin cancer.

SAFETY SUMMARY-CONTINUED

PURGING

When purging a Tank, all piping and valves become hot enough to burn. Ensure Tank components are at ambient temperatures before attempting handling or removal after purging operation.

WELDING AND BRAZING

Welding or brazing operations produce heat, metal fumes, injurous radiation, metal slag, and airborne particles. Proper equipment must be worn before welding or brazing. Never look directly at the arc when welding or the flame during brazing. Never attempt welding or brazing near Teflon components (e.g. anti-seize tape). Teflon components deteriorate at high temperatures and emit poisonous gases. Proper ventilation is a must when welding or brazing.

TANK VACUUM

Never break the vacuum in the annular space with liquid product in the Tank. The liquid product must be drained.

PAINTING

Paint and coatings may affect skin, eyes, and respiratory functions. Proper ventilation is a must and avoid repeated contact when possible.

SECTION I

INTRODUCTION AND GENERAL INFORMATION

1-1 INTRODUCTION.

This technical manual contains operation, service, and repair instructions for the Type TMU-20/E Skid-Mounted 5,000 Gallon Liquid Oxygen/Nitrogen Storage Tank, manufactured by the LOX EQUIPMENT COMPANY, Delphi, Indiana. Only fully trained and qualified personnel will be authorized to operate or handle any equipment involving liquid nitrogen.

1-1.1 Purpose. This technical manual will provide the using activity with operation and service instructions for the Liquid Oxygen/Nitrogen Storage and Transfer Tank, Type TMU-20/E.

1-1.2 Scope. This manual will provide the using activity with applicable information required on the filling, storage, and transfer of liquid nitrogen, also the hazards associated with the use of cryogenic equipment and products. Any corrections regarding this technical manual should be submitted in accordance with T.O. 00-5-1.

1-1.3 Arrangement. Arrangement of this manual is in sections. Each section covers a particular function in relation to the Tank and product. Sections may reference other sections within this manual and other manuals which also cover this Tank. References made within this manual will normally be for figures, tables, sections, and paragraphs. Operation and maintenance instructions are provided in the form of procedural steps assuming that authorized personnel have previous experience with similar or related equipment.

1-2 GENERAL INFORMATION.

1-2.1 Purpose of Equipment. The Tank is intended for the storage and transfer of liquid aviator's breathing oxygen. Conversion of this Tank to store liquid nitrogen is authorized only as provided by AF Regulation 54-7.

1-2.2 Physical Description. The Tank is a composite of assemblies as follows:

a. Tank. The Tank is a complete, self-contained, skid-mounted unit. It has been designed to store liquid oxygen/nitrogen with a low evaporation rate and transfer the liquid into smaller servicing tanks. Forklift slots in the skid and tiedown rings on the sides of the Tank have been provided for lifting requirements.

b. Shells. The Tank consists of an inner shell suspended inside an outer shell. The space between the shells is called the annular space which is insulated and holds a vacuum.

c. Control Housing. The control housing, located at the front of the Tank, protects and contains the operating controls and indicators.

d. Pressure Buildup Coil (PBC). The PBC is located inside the control housing directly under the Tank fill/drain and servicing lines. The PBC performs as a heat-exchanger where the liquid oxygen/nitrogen is converted into gaseous oxygen. This conversion provides pressure within the inner shell for product transfer and drainage.

e. Relief Devices. The Tank contains relief devices which protect against pressure buildups in the inner shell, fill/drain line, and servicing line that exceed the design parameters.

f. Control Panel. The control panel contains the Tank indicators for determining liquid pressure levels within the inner shell. Located below the indicators are the indicator valves and the operating instructions with the Tank flow schematic diagram plaque.

g. Fill/Drain Line (FDL). The FDL is located within the control housing. This line allows the Tank to be filled and drained of product. The FDL components consist of a control valve, relief valve, drain valve, filter, and LOX coupling.

h. Servicing Line (SL). The SL is located within the control housing. This line allows servicing of smaller tanks which in turn service the aircraft. The SL consists of a control valve, relief valve, drain valve, filter, LOX coupling, and service hose.

i. Vapor Vent Manifold (VVM). The VVM and its components are located within the control housing. The vent is located outside of the control housing. This line allows inner shell pressures to be vented outside away from the operating area. VVM components consist of a control valve,

relief valve, inner shell safety head, and adjustable pressure control valve.

1-2.3 Leading Particulars. A summary of leading particulars for the Tank appears in Table 1-1.

Table 1-1. Leading Particulars

Identification:	Liquid Oxygen/Nitrogen Storage Tank, Type TMU-20/E
Manufacturer:	LOX EQUIPMENT COMPANY - Delphi, Indiana
Part Number(s):	80-507 & SV-50-LN-SK
National Stock Number (NSN)	3655-01-105-8765YD & 3655-01-263-7635YD
Capacity:	
Gross Volume	5338 gallons
Net Volume	5000 gallons
Weight:	
Empty	20,000 pounds
Full (Oxygen)	65,570 pounds
(Nitrogen)	53,745 pounds
Evaporation Rate:	
Oxygen	Less than 1/4 percent per 24 hour day.
Nitrogen	Less than 1/2 percent per 24 hour day.
Overall Dimensions:	
Length	25 ft. - 0 in.
Width	8 ft. - 11 in.
Height	9 ft. - 11-3/4 in.
Operating Pressure (Inner Tank):	55 psig
Maximum Allowable Working Pressure (MAWP):	64 psig
Relief Valve Settings:	
Inner Tank (RV-3)	
Fill/Drain Line (RV-2)	
Servicing Line (RV-1)	
Safety Head Settings:	
Inner Tank (SD-1)	
Annular Space (SD-2)	

1-2.4 Related Publications. The publications listed in Table 1-2 are required and shall be used with this publication, the Repair and Overhaul Instructions, T.O. 37C2-8-19-13 and the Illustrated Parts Breakdown, T.O. 37C2-8-19-14 in the operation, maintenance, service, and repair of the Tank.

1-2.5 Safety Precautions. Safety precautions related to liquid oxygen/nitrogen and this Tank are listed in the Safety Summary. Safety precautions which are related to specific procedures will appear in the text.

1-2.6 Properties of Liquid Oxygen (LOX) and Liquid Nitrogen (LIN). LOX is a pale blue, nonviscuous, water-like fluid. At atmospheric pressure it is 1.14 times heavier than water and weighs 9.527 pounds per gallon. LOX boils at -297°F. When LOX is converted to a gaseous state, it expands to about 860 times its original volume. One cubic foot of LOX (7.5 gallons) will expand to about 860 cubic feet of gaseous oxygen at 70°F. For additional information about LOX, refer to T.O. 42B6-1-1.

LIN is inert, colorless, odorless, noncorrosive, extremely cold, and nonflammable. Nitrogen is inert except when heated to very high temperatures, when it is combined with metals to form nitrides, oxygen to form oxides of nitrogen, and when combined with hydrogen in the presence of catalysts to form ammonia.

Since nitrogen in noncorrosive, special materials of construction are not required, except that they must be suitable for use at the temperatures of liquid nitrogen.

Nitrogen, although used chiefly in the gaseous state, is often stored as a liquid because liquid storage in less bulky and less costly than the equivalent capacity of high pressure gas storage. Liquid nitrogen storage systems are insulated or vacuum insulated to minimize product losses through vaporization.

Table 1-2. Related Publications.

Publication No.	Title
T.O. 00-5-1	AF Technical Order System
T.O. 00-25-107	AFLC Area Support
T.O. 00-25-172	Ground Servicing of Aircraft and Static Grounding/Bonding
T.O. 00-25-223	Integrated Pressure Systems and Components
T.O. 00-25-252	Welding High Pressure and Cryogenic Systems
T.O. 00-25-229	Valves and Regulators
T.O. 33D2-10-60-1	Cryogenic Sampler
T.O. 34Y5-3-37-1	Operation and Maintenance Instructions Poer Driven Rotary Vacuum Pump
T.O. 00-35D-54	USAF Material Deficiency Reporting and Investigating System
T.O. 35-1-3	Painting and Marking of USAF Aerospace Ground Equipment
T.O. 37C2-8-19-3	Liquid Oxygen/Nitrogen Storage Tank, Overhaul and Repair Instructions
T.O. 37C2-8-19-4	Liquid Oxygen/Nitrogen Storage Tank, Illustrated Parts Breakdown
T.O. 37C2-8-1-116WC-1	Inspection Work Cards
T.O. 37C2-8-27-11	Operation, Maintenance and Overhaul Instructions with Illustrated Parts Breakdown Meter, Dual Efficiency
T.O. 37C11-3-1	Vacuum Gauge (Portable), Part No. 15840
T.O. 36G2-3-1	Air Purging Unit, Type GSU-62/M
T.O. 37C11-1-1	Cleaning of Pressure Gauges Used
T.O. 42B6-1-1	Quality Control of Oxygen
AFOSH-STD-127-66	Occupational Safety General Industrial Operations
AFR-144-1	Fuels Management
MIL-STD-1359A	Cleaning Methods and Procedures for Breathing Oxygen Equipment

1-3. CONSUMMABLE MATERIALS LIST.
Materials used in the maintenance of the Tank at the operating level are listed in Table 1-3.

Table 1-3. Consumable Materials List

Material	Specifications	Federal Stock No.
Tape, Antiseize (1/2 inch)	MIL-T-27730A	8030-00-889-3535
Nitrogen	BB-N-411	6830-00-285-4769
Leak Detection Compound, Oxygen Systems, Type 1	MIL-L-25567C	6850-00-621-1820
Solvent, trichlorotrifluoroethane	MIL-C-81302	6850-00-681-5688

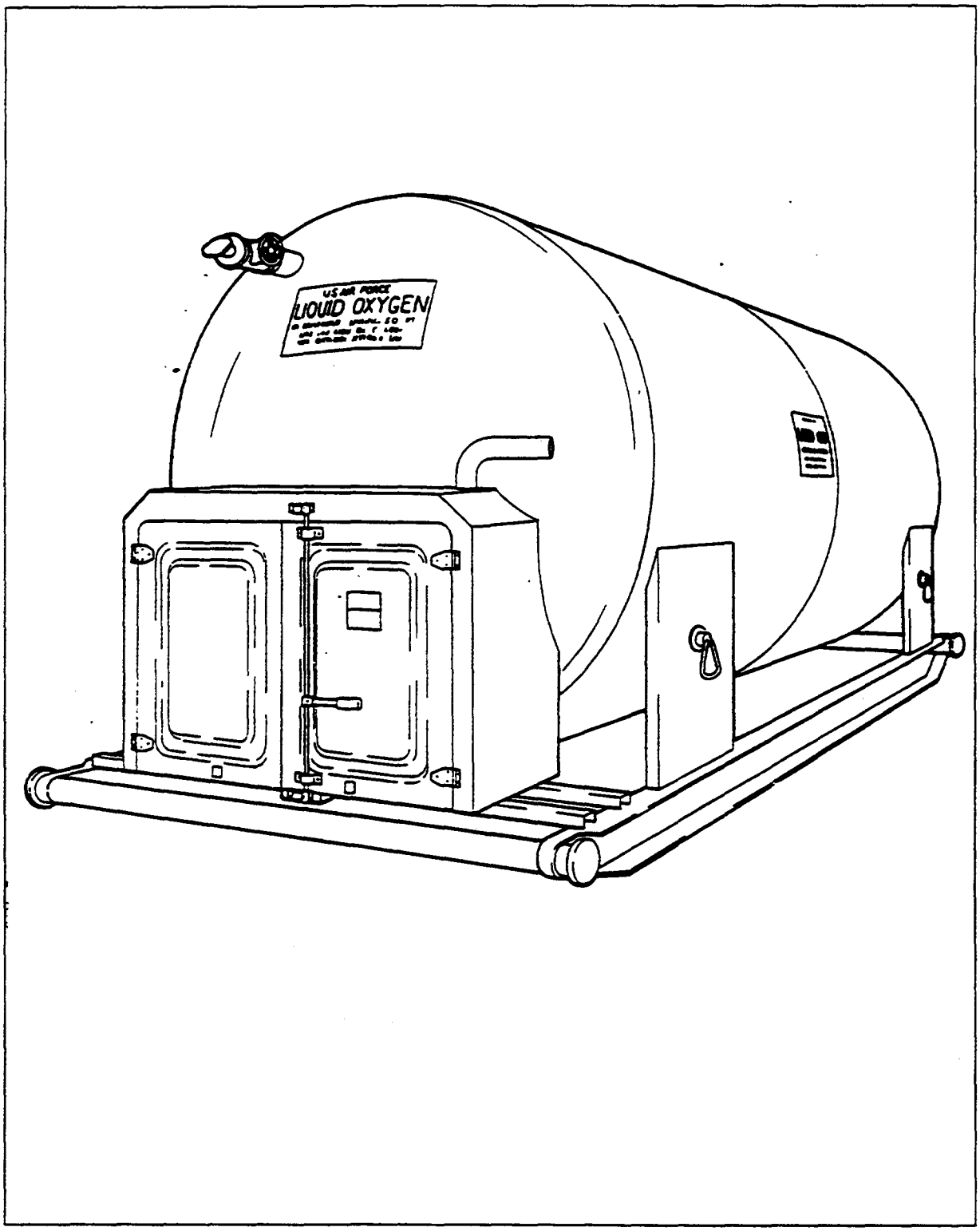


Figure 1-1. 5000 Gallon Liquid Oxygen/Nitrogen Storage Tank, Type TMU-20/E.

SECTION II

SPECIAL TOOLS AND EQUIPMENT

2-1 GENERAL.

2-1.1 Special tools and equipment required to operate and maintain the Tank are listed in Table 2-1. Items recommended (Figure 2-1, Figure 2-2) are approved tools and test equipment if available. However, equivalent items may be used if recommended items are not available.

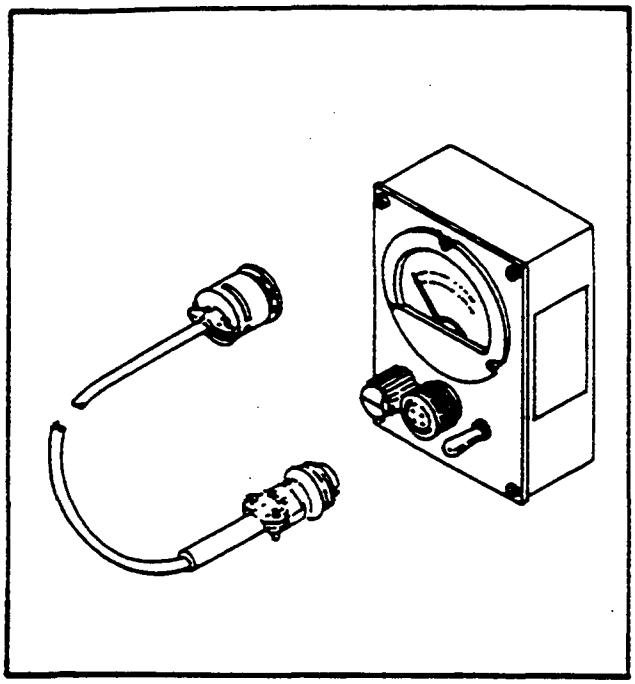


Figure 2-1. Vacuum Gauge

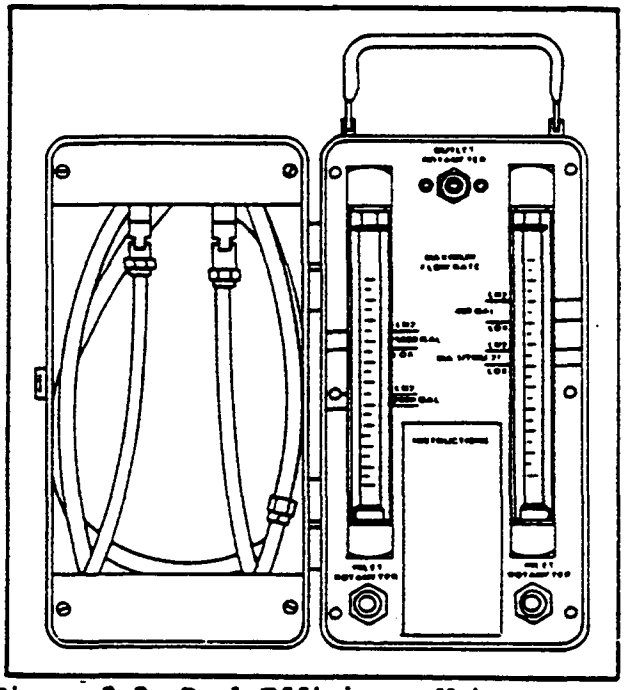


Figure 2-2. Dual Efficiency Meter

Table 2-1. Special Tools and Equipment List

Tool/Equipment Number	Figure Number	Nomenclature	Use and Application
Part No. 15840 NSN 6685-00-115-9602YD	2-1	Vacuum Gauge	Determine annulus vacuum level
Part No. 50C-0016-1 NSN 6680-01-117-9931YD	2-2	Dual Efficiency Meter	Check boil-off rate to determine efficiency of annulus vacuum

SECTION III

PREPARATION FOR USE AND SHIPMENT

3-1 GENERAL.

3-1.1 Scope. This section describes the requirements for the Using Activity when a tank is received from the manufacturer.

3-2 PREPARATION FOR USE.

3-2.1 Preparing the Tank. Before a Tank can be put into service, filles with product, or used in transfer operations certain precautions must be accomplished by authorized personnel.

3-2.2 Tank Condition Upon Receipt. When received from the manufacturer, the Tank is shipped with the inner shell pressurized with 10-20 psig of clean, dry, oil-free nitrogen gas. All valves are closed and the discharge vent is sealed with pressure sensitive tape. The annular space, between the inner and outer shells, has been evacuated to the desired vacuum.

3-3 EXTERNAL SURFACES.

3-3.1 Preparation. The following are items which should be accomplished upon receipt of Tank.

a. Packing. All external packing used for shipment from the manufacturer must be removed.

b. Cleaning. Remove any oil, grease or other hydrocarbons from the outside surfaces of the Tank with trichlorotrifluoroethane (MIL-C-81302). Observe all safety precautions when using solvents.

c. Inspection. The Tank is given a complete operational and visual inspection before being shipped fronm the manufacturer. Upon receipt the Tank should be visually inspected for possible damage during shipment or if it is being removed from dry storage before being placed into service. All valves should be closed but if any valves were left open, suspect contamination. A basic receiving inspection should include these items:

[1] Inspect the outside of the Tank and inside the control housing for components and piping damage which might affect performance or safety.

CAUTION

Do not check the vacuum line shutoff valve (V-1) or the vacuum indicator shutoff valve (V-2) during valve inspection. Tampering with these valves can result in vacuum loss.

[2] Check all valves for smooth positive operation. Make sure that the valves are left closed after inspection.

[3] Check all welds for indications of cracks.

[4] Check for rust or corrosion.

[5] Make sure that all couplings and vent openings are clean and free from obstructions.

d. Checking Vacuum. Checking the Tank vacuum within the annular space requires a vacuum gauge (Refer to Table 2-1 and See Figure 2-1). Procedures for checking the Tank vacuum are found in section V (Refer to paragraph 5-5.4 and See Figure 5-4).

3-4 LOCATION.

3-4.1 Selection of an Operating Site. Publications used in establishing proper locations for liquid oxygen tanks are listed in Table 1-2.

3-4.2 Type Site. To avoid the accumulation of oxygen vapors from leakage and venting the Tank shall be located in a well-ventilated area. The Tank will be placed on a permanent or semi-permanent location with a smooth, level foundation for proper operation. A concrete surface of sufficient size to accomodate transfer operations by delivery vehicles shall be uitlized.

3-5 PREPARATION FOR SHIPMENT AND SHIPMENT.

3-5.1 Prior to shipment or storage, certain preparations and tasks must be accomplished. This Tank HAS NOT been designated for shipment with product.

3-5.2 General Preparations. Prior to shipment or storage, certain procedures and tasks must be accomplished. These tasks must be completed in the order as follows:

a. Drain the Tank of all liquid product (Refer to Section IV).

b. Purge the Tank and pressurize the inner shell with 10-20 psig of clean, dry, oil-free nitrogen gas (Refer to Section V, T.O. 37C2-8-19-11 Paragrpah 5-7).

c. Check the Tank vacuum (Refer to Section V in this publication).

d. Lifting and moving the Tank (Refer to paragraph 3-7 in this section).

3-5.3 Tank Shipment. After the Tank has been properly prepared it is ready for shipment (Air or ground). While the Tank is not fragile, it should not be subjected to any sudden vertical or horizontal acceleration. DO NOT DROP. Markings for shipment shall be in accordance with MIL-STD-129.

3-5.4 Tank Storage. Prior to storage, the Tank must be prepared as follows:

a. Accomplish steps a thru c as outlined in paragraph 3-5.2 in this section.

b. Clean the exterior of the Tank (See paragraph 3-3, b, in this section). All loose or chipped paint and all solvents must be removed. If necessary, paint the Tank in accordance with T.O. 35-1-3.

c. Replace all damaged decals.

d. Prepare a tag (Specification UU-T-81 or equivalent) to indicate the date of preparation for storage, the pressure of the dry nitrogen in the inner shell, the date and level of vacuum, and the date of the last evacuation.

3-6 STATIC GROUNDING.

3-6.1 Grounding Requirements. Prior to designated operations the Tank shall be grounded against the effects of static electricity (See Figure 3-1).

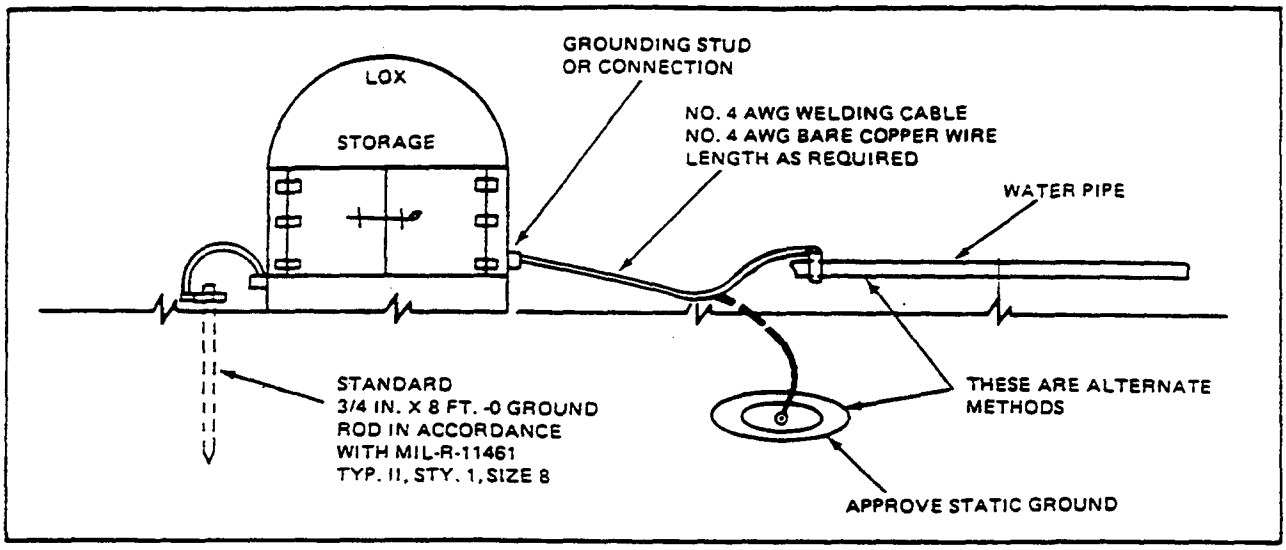


Figure 3-1. Approved Method for Static Grounding.

3-7 LIFTING AND MOVING THE TANK.

3-7.1 Lifting and Moving Methods. (See Figure 3-2). The Tank can be lifted and moved by two (2) methods as follows:

CAUTION

Do not jerk or drop the Tank during any lifting and moving operation.

a. Crane Lifting. When using a crane for lifting and moving the Tank, the lifting assemblies (e.g. slings, cables, or chains) shall have sufficient rating for the Tank weight (20,000 pounds) and G-Loads generated by the Tank weight. The following are minimum requirements for lifting assemblies:

[1] The minimum length of EACH lifiting assembly shall be nine (9) feet in length from the lifitng eye to the point of lifting.

[2] The minimum rating of EACH lifting assembly shall be 10,000 pounds. This requirement is based upon the tension on each lifitng assembly of 7,750 pounds at two (2) G's (1 G is equal to the weight of the Tank). If liting assemblies of minimum requirements are not available, then a combination of components to meet the minimum requirements is acceptable. Each component must meet the minimum requirements. Attach the lifitng assemblies to the top lift rings on the sides of the Tank. Maintain a hoisting angle of at least 60 degrees from the horizontal for safe effficient lifting (maintaining the nine (9) foot length will insure the 60 degree or larger angle). If a spreader bar is to be used, make sure its rating is sufficient for the weight involved.

b. Forklift Lifting. When using a forklift for lifting and moving the Tank, the lifting capacity of the forklift must be sufficient for the weight of the Tank (20,000 pounds). If a single forklift of sufficient capacity is not available, then a combination of forklifts may be used if the combined lifting capacity is adequate for the weight involved. Six (6) forklift slots have been provided in the skid frame on each side of the Tank. Make sure the forklift tines are fully inserted in these slots before attempting to lift the Tank. Maintain the Tank in a horizontal position during lifitng and moving the Tank.

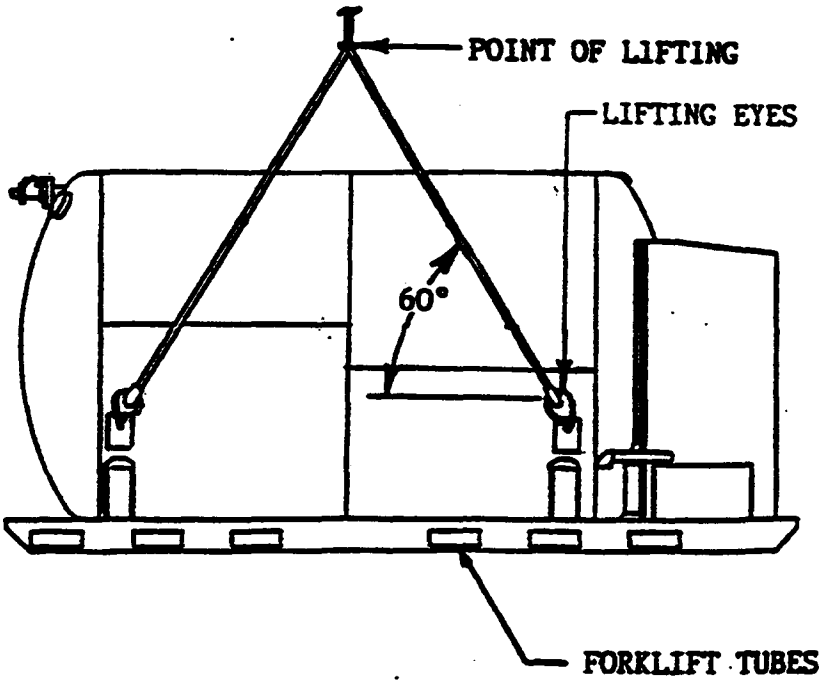


Figure 3-2. Lifting Instructions.

SECTION IV

OPERATION INSTRUCTIONS

4-1 THEORY OF OPERATION

(See figure 4-1 and figure 6-1).

4-1.1 General Description. The Tank is self-contained, skid mounted unit designed to be filled with product (LOX), store the product until needed, and transfer the product to smaller aircraft servicing tanks. The design incorporates two shells with one shell (inner) suspended inside the other shell (outer). The inner shell contains the product and the outer shell contains the insulation and vacuum which is also called the annular space. The annular space provides a heat barrier to prevent the loss (boil-off) of product within the inner shell.

4-1.2 Transfer of Product. The transfer of product is accomplished by use of a pressure difference. The pressure required for transfer operations is created by the pressure buildup coil (PBC). The PBC acts as a heat exchanger which changes liquid product into gas through vaporization. The gaseous product fills the area within the inner shell above the liquid product thereby creating a positive pressure for product transfer. When the inner shell pressure is greater than the receiving tank pressure, the physical requirements exist for product transfer.

4-2 OPERATING CONTROLS

(See figure 4-1).

4-2.1 Purpose and Use of Operating Controls. The purpose and use of the Tank operating controls is as follows:

a. Servicing Line Shutoff Valve (V-5). The purpose of V-5 is to start and stop the flow of product through the servicing line. V-5 is used by the operator when servicing receiving tanks to start, control and stop the flow of product.

b. Servicing Line Drain Valve (V-6). The purpose of V-6 is to drain off pressure from the servicing line. V-6 is used by the operator to drain servicing line pressure before disconnecting the service hose after transfer operations.

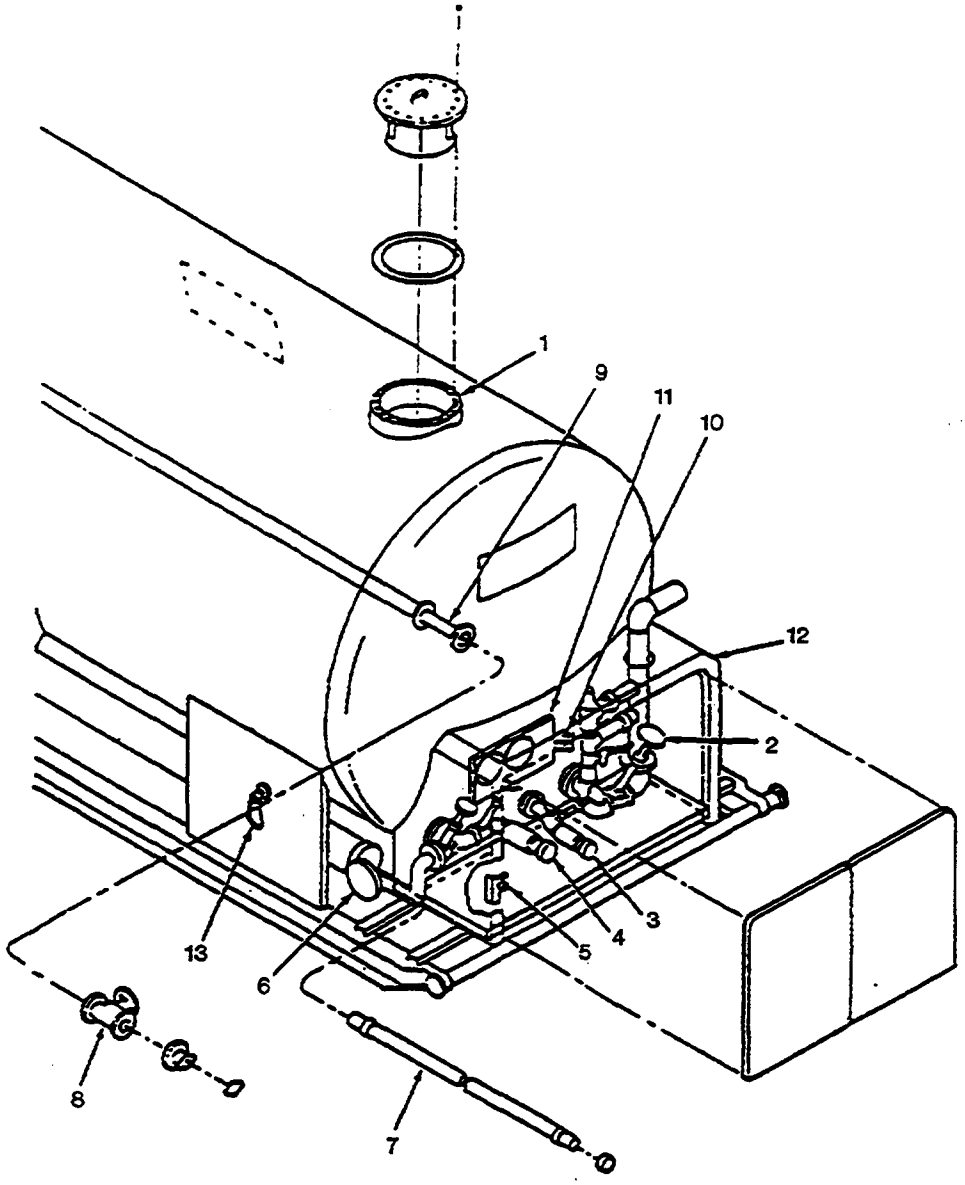
c. Fill/Drain Line (FDL) Shutoff Valve (V-8). The purpose of V-8 is to start and stop flow of product through the FDL. V-8 is used by the operator when filling or draining the Tank to start, control and stop the flow of product.

d. Fill/Drain Line (FDL) Drain Valve (V-7). The purpose of V-7 is to drain off pressure from the FDL. V-7 is used by the operator to drain FDL pressure before disconnecting the hose used in fill and drain operations.

e. Pressure Buildup Coil (PBC) Shutoff Valve (V-9). The purpose of V-9 is to allow liquid product flow to the PBC. V-9 is used by the operator for building pressure within the inner shell. Once the operating pressure for the inner shell is obtained, V-9 is used to replace pressure losses that may occur during Tank operations.

f. Vapor Vent Line (VVL) Shutoff Valve (V-10). The purpose of V-10 is to vent gaseous product within the inner shell. V-10 is used by the operator during Tank operations for relieving inner shell pressure which exceed the normal operating pressure. V-10 is also used (left open) when the Tank is in idle mode.

g. Adjustable Pressure Control Valve (PC-1). The purpose of PC-1 is to allow automatic venting of inner shell pressure in order to maintain the inner shell pressure at the desired level.



1. MANWAY
2. TANK VENT SPOOL ASSEMBLY
3. SERVICE LINE SPOOL ASSEMBLY
4. FILL AND DRAIN SPOOL ASSEMBLY
5. FULL TRYCOCK VALVE
6. SERVICE HOSE STORAGE TUBE
7. SERVICE HOSE
8. EVACUATION VALVE
9. EVAUCATION FILTER SPOOL ASSEMBLY
10. VACUUM INDICATOR CONNECTION
11. PRESSURE AND CAPACITY GAUGES
12. HOUSING
13. LIFTING RING (4 PLACES)

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Figure 4-1. Component Identification.

h. Level Indicator Isolation Valve (Vapor) (V-11). The purpose of V-11 is to isolate the vapor phase pressure indicator (PI-1) from the gaseous pressure in the inner shell. V-11 is used by the operator to zero (0) the Tank liquid level indicator (LL-1). V-11 is used by maintenance personnel to prevent gaseous product flow through the V-10 lines when replacing LL-1 or the level indicator equalizer valve (V-3).

i. Level Indicator Isolation Valve (Liquid) (V-12). The purpose of V-12 is to isolate the Tank liquid level indicator (LL-1) from the liquid pressure in the inner shell. V-12 is used by the maintenance personnel to prevent product flow through the V-12 lines when replacing LL-1 or the level indicator equalizer valve (V-3).

j. Level Indicator Equalizer Valve (V-3). The purpose of V-3 is to isolate between the level indicator isolation valves (V-11 and V-12). V-3 is used by the operator to zero (0) the Tank liquid level indicator (LL-1), normally closed.

k. Full Trycock Valve (V-2). The purpose of V-2 is to indicate when the Tank is at or near its full capacity. V-2 is used by the operator during filling operations. When liquid streams from V-2, the Tank is near or at full capacity.

4-3 ADDITIONAL TANK EQUIPMENT.

4-3.1 Purpose and Use of Additional Tank Equipment (See figure 4-1). The purpose of other Tank components is as follows:

a. Vacuum Line Shutoff Valve (V-1). The purpose of V-1 is to provide a means for pumping out the annular space thus creating a vacuum between the inner and outer shell. V-1 is used by maintenance personnel during pump out operations to attach the pump out hose and to isolate the annular space after pump out operations have been completed.

b. Vacuum Indicator Shutoff Valve (V-4). The purpose of V-4 is to isolate the annular space which holds the vacuum from the vacuum sensor (thermocouple). V-4 is the used by maintenance personnel when a vacuum check is required for the Tank.

c. Vacuum Sensor (Thermocouple) (T-13). The purpose of the vacuum sensor is to provide a means of attaching a vacuum gauge. The vacuum sensor is used by maintenance personnel when taking a required vacuum reading of the annular space.

d. Pressure Buildup Coil (PBC). The purpose of the PBC is to convert liquid product into gaseous product. The PBC is used by the operator to build pressure within the inner shell for Tank operations.

e. Service Hose. The purpose of the service hose is to provide a means of transferring liquid product to receiving tanks. The service hose is used by the operator when servicing tanks during transfer operations.

f. Servicing Line Filter (F-1). The purpose of F-1 is to filter impurities when servicing other tanks. F-1 is used during operations but does not contain any control devices. When required, F-1 is changed by maintenance personnel and recycled after being cleaned.

g. Fill/Drain Line Filter (F-2). The purpose of F-2 is to filter impurities when being filled by delivery vehicles. F-2 is used during operations but does not contain any control devices. When required, F-2 is changed by maintenance personnel and recycled after being cleaned.

h. Servicing Line (SL) Pressure Relief Valve (RV-1). The purpose of RV-1 is to relieve pressure buildup in the SL. RV-1 is used as a safety device during and after servicing operations in the event that liquid product becomes trapped in the SL. RV-1 operates and resets automatically.

i. Fill/Drain Line (FDL) Pressure Relief Valve (RV-2). The purpose of RV-2 is to relieve pressure buildup in the FDL. RV-2 is used as a safety device during and after filling and draining operations in the event that liquid product is trapped in the FDL. RV-2 operates and resets automatically.

j. Inner Shell Pressure Relief Valve (RV-3). The purpose of RV-3 is to relieve pressure buildup within the inner shell. RV-3 is used as a safety device if over pressure conditions develope within the inner shell during operations or when the Tank is in the idle mode. RV-3 operates and resets automatically.

k. Inner Shell Safety Head (SD-1). The purpose of SD-1 is to relieve shell pressure buildup if the inner shell pressure relief valve (RV-3) fails to open. SD-1 is used as a safety device if RV-3 fails to operate when inner shell pressure exceeds safe limits. SD-1 must be replaced by maintenance personnel if it ruptures.

l. Outer Shell Safety Head (SD-2). The purpose of SD-2 is to relieve any pressure buildup within the annular space. SD-1 is used as a safety device for the outer shell if a leak developes on the inner shell. SD-2 can also indicate that the vacuum has been lost within the annular space.

m. Tank Liquid Level Indicator (LL-1). The purpose of LL-1 is to indicate the level of liquid product inside the inner shell. LL-1 is used by the operator in determining if enough product exists within the inner shell to perform servicing operations, if the Tank needs to be filled with product and the capacity requirements of the receiving tank should the Tank need to be drained.

n. Vapor Phase Pressure Indicator (PI-1). The purpose of PI-1 is to indicate the pressure within the inner shell. PI-1 is used by the operator to determine when normal operating pressure for Tank operations is sufficient, when operating pressure needs to be increased during operations, and when operating pressure begins to exceed safe limits.

4-4 OPERATING INSTRUCTIONS.

4-4.1 Basic Instructions. All operating controls appear in figure 4-1 and the basic valve positions for each function is shown in table 4-1. There is a procedure to be followed for each function. Operational procedures are outlined in the following paragraphs.

4-5 FILLING THE TANK.

4-5.1 Types of Fillings. Two separate procedures exist for filling a Tank. One procedure is for a Tank that is ambient or a Tank that has been purged. The other procedure is for a Tank that is chelled due to an amount of product still in the inner shell. The following are basic requirements before filling an ambient/purged or chilled Tank. These requirements are as follows:

a. Review the Safety Summary.

b. Wear protective equipment.

c. Use caution when disconnecting the supply hose from the fill/drain line LOX coupling.

4-5.2 Filling an Ambient/Purged Tank (See figure 4-1). Follow these procedures during the first filling of a Tank, filling a Tank that has been out of service, or any time that the inner shell is at ambient temperature. These procedures will allow the inner shell to chill evenly and avoid possible deformation and excessive loss of product. The following procedure is as follows:

a. Remove dust caps, purge and connect the supply hose from the supply source to the fill/drain line (FDL) coupling.

Table 4-1. Valve Positions During Tank Operations.

Valve Tag ID	Tank Filling	Pressure Buildup	LIN Transfer	Gravity Drain	Pressure Drain	Constant Pressure	Liquid Storage	Tank Empty
V-3	Closed	Closed	Open	Closed	Closed	Closed	Closed	Closed
V-4	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
V-5	Open	Closed	Closed	Open	Open	Closed	Closed	Closed
V-6	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
V-7	Closed	Open	*	Closed	Open	Closed	Closed	Closed
V-8	Open	Closed	Closed	Open	Closed	Closed	Closed	Closed
V-9	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed
PC-1	**	**	**	**	**	Auto.	**	**

* V-9 may be opened intermittently during product transfer to maintain desired pressure.

** PC-1 is set to relieve automatically as a predetermined pressure for constant pressure operation. This automatic feature may interfere with such other operations as pressure buildup, filling, transfer and pressure drain. PC-1 may have to be set to a higher pressure, depending on the particular operation.

b. Open the full trycock valve (V-2).

c. Open the vapor vent line shutoff valve (V-10).

d. Open the liquid level isolation valves (V-11) and (V-12).

e. Check and adjust the adjustable pressure control valve (PC-1), if necessary.

f. Open the FDL shutoff valve (V-8).

g. Check that all other valves not required for filling operation are closed.

h. Slowly open the supply source valve and maintain 10 psig during initial filling of a warm tank.

CAUTION

Do not exceed the 5000 gallon capacity of the Tank.

i. Close the source valve when liquid product begins to spurt from the full trycock valve's discharge line.

j. Quickly, close the (V-8) and open the FDL drain valve (V-7) to drain trapped product in the supply hose.

k. Disconnect the supply hose, close (V-7) and install dust caps on couplings.

l. Close (V-10) and (V-2) after excessive venting has stabilized.

NOTE

After the Tank is filled, fluctuating pressures may cause an inaccurate display on the Tank liquid level indicator until the Tank has stabilized.

m. Check product quantity on the liquid level indicator (LL-1).

n. Open (V-10), if no additional Tank operations are scheduled, placing the Tank in the idle mode.

4-5.3 Filling a Chilled Tank (See figure 4-1). Follow these procedures when filling a Tank that is low on liquid product. The procedure is as follows:

a. Open the fill/drain line (FDL) drain valve (V-7) to make sure no product is under pressure, due to a leaking FDL shutoff valve (V-8). If no product vents then close (V-7).

b. Remove dust caps, purge and connect the supply hose from the supply source to the FDL coupling.

c. Open the full trycock valve (V-2).

d. Open the vapor vent line shutoff valve (V-10).

e. Open the liquid level isolation valves (V-11) and (V-12).

f. Check and adjust the adjustable pressure control valve (PC-1), if necessary.

g. Open the FDL shutoff valve (V-8).

h. Check that all other valves not required for filling operations are closed.

i. Slowly open the supply source valve and transfer will begin.

CAUTION

Do not exceed the 5000 gallon capacity of the Tank.

j. Close the source valve when liquid product begins to spurt from the full trycock's discharge line.

k. Quickly, close (V-8) and (V-7) to drain trapped product in the supply hose.

l. Disconnect service hose, close (V-7) and install dust caps on couplings.

m. Close (V-10) and (V-2) after excessive venting has stabilized.

NOTE

After the Tank is filled, fluctuating pressures may cause an inaccurate display on the Tank liquid level indicator until the Tank has stabilized.

n. Check Tank quantity on the liquid level indicator (LL-1).

o. Open (V-10), if no additional Tank operations are scheduled, placing the Tank in the idle mode.

4-6 SERVICING WITH THE TANK

4-6.1 Servicing Tanks with Product (See figure 4-1). The Tank is designed to operate at pressures up to 50 psig. Observe all safety precautions and wear protective clothing. Use caution when disconnecting the servicing hose. When transferring product the procedures are as follows:

a. Open the servicing line (SL) drain valve (V-6) to make sure no product is under pressure, due to a leaking SL shutoff valve (V-5). If no product vents then close (V-6).

b. Prepare the receiving tank to be serviced by the Tank in accordance with applicable Technical Orders.

c. Check that all valves are closed except the liquid level isolation valves (V-11) and (V-12).

d. Check and adjust the adjustable pressure control valve (PC-1), if necessary.

CAUTION

Do not exceed the operating pressure of 55 psig.

e. Slowly, open the pressure buildup control valve (V-9) and build pressure to 50 psig on the vapor phase pressure indicator (PI-1). Operate (V-9) and vapor vent line shutoff valve (V-10) as necessary to maintain transfer pressure.

f. Remove service hose (7) from the control housing. Remove the dust cap and purge service hose by opening (V-5). Close (V-5) after purging.

g. Connect the service hose to the receiving tank fill coupling.

h. Open the receiving tank fill valve and SLOWLY open (V-5). Fill the receiving tank to the desired level.

i. After the receiving tank has been serviced, close (V-5) and the receiving tank fill valve.

j. Quickly, open (V-6) to drain the product and pressure from the service hose. After draining the service hose, close (V-6).

NOTE

If more than one receiving tank is to be filled, retain the pressure in the Tank until all transfers have been completed.

k. Open (V-10) to relieve Tank pressure. Disconnect the service hose, install the dust cap on the coupling and return the service hose to the control housing.

l. If no additional Tank operations are scheduled, leave (V-10) open, placing Tank in the idle mode.

4-7 DRAINING THE TANK.

4-7.1 Draining Product from the Tank (See figure 4-1). The Tank can be drained by gravity or by pressure. If gravity draining is desired, the operator only needs to open the fill/drain line (FDL) shutoff valve (V-8) after making the proper connections. Follow these procedures when pressure draining the Tank:

WARNING

Ensure that the container and area is free of all hydrocarbons.

a. Connect a suitable hose to the fill/drain line (FDL) coupling and to a suitable container.

NOTE

The Tank can be drained using the servicing line if desired.

b. Ensure all valves are closed except the liquid level isolation valves (V-11) and (V-12).

c. Check and adjust the adjustable pressure control (PC-1), if necessary.

CAUTION

Do not exceed the operating pressure of 55 psig.

d. Slowly, open the pressure buildup control valve (V-9) and build draining pressure desired by monitoring the vapor phase pressure indicator (PI-1). If necessary, operate (V-9) to maintain draining pressure.

e. Open the FDL shutoff valve (V-8) and drain the Tank until product flow ceases and (PI-1) reads zero (0).

f. Close (V-8) and (V-9) if necessary.

g. Disconnect the hose from the FDL coupling and re-install the dust cap.

4-8 PRODUCT SAMPLING.

4-8.1 Obtaining Product Samples (See figure 4-1). Periodically it will be necessary to obtain samples of the product for testing (refer to T.O. 37C2-8-1-116WC-1). Observe all safety precautions, wear protective clothing and equipment, and use caution when disconnecting sampler hoses. Follow these procedures when draining product samples from the Tank:

a. Open the servicing line (SL) drain valve (V-6) to ensure there is no leakage from the SL shutoff valve (V-5) (4). Close (V-6) if no product vents.

b. Prepare the sampler in accordance with applicable Technical Orders.

c. Check that all valves are closed except the liquid level isolation valves (V-11) and (V-12).

d. Check and adjust the adjustable pressure control valve (PC-1), if necessary.

CAUTION

Do not exceed the operating pressure of 55 psig.

e. Slowly, open the pressure buildup control valve (V-9) and build pressure to 50 psig on the vapor phase pressure indicator (PI-1). Operate (V-9) and

vapor vent line shutoff valve (V-10) as necessary to maintain transfer pressure.

f. Remove service hose (7) from the control housing. Remove the dust cap and purge the service hose by opening (V-5). Close (V-5) after purging.

g. Connect the service hose to the product sampler.

h. Prepare the sampler and SLOWLY open (V-5).

i. After the sample has been taken, close (V-5).

j. Quickly, open (V-6) to drain the product and pressure from the service hose. After draining the service hose close (V-6).

k. Open (V-10) to relieve Tank pressure. Disconnect the service hose from the sampler, install dust cap on the coupling and return the service hose to the control housing.

l. Dispose of the product sample in accordance with proper directives.

NOTE

When purging is indicated by unsatisfactory sample of the product refer to the Repair and Overhaul Instructions, T.O. 37C2-8-19-13 and T.O. 37C2-8-19-14 for purging procedures.

SECTION V

MAINTENANCE INSTRUCTIONS

5-1 INSPECTION AND PREVENTATIVE MAINTENANCE.

5-1.1 Scope. This section contains the necessary procedures for maintaing the Tank when it contains liquid product. Only qualified personnel shall be authorized to perform maintenance on the Tank. Maintenance personnel must keep parts being removed and replaced free from hydrocarbons.

5-1.2 Periodic Inspection. Refer to T.O. 37C2-8-1-116WC-1 (Inspection Cards).

5-1.3 Periodic Lubrication. No periodic lubrications is required for this Tank.

5-1.4 Troubleshooting. Refer to Table 5-1 for troubleshooting procedures for common malfunctions, probable causes, and remedies. Component references are to Figure 4-1.

5-1.5 General Maintenance Instructions. Maintenance personnel must keep all parts used in handling liquid oxygen free from hydrocarbons. All parts that are removed or left exposed on the Tank must be sealed in polyethylene bags until reassembly. All anti-seize tape must be removed and replaced on threaded parts. When replacing anti-seize tape start with the third thread from the end.

5-1.6 Clogged Filters. A clogged filter should be suspected whenever flow is reduced through the servicing or fill/drain lines with the valve fully opened and the Tank pressurized. Filters may be changed at the operational level in accordance with the following instructions in this section.

5-2 FILL/DRAIN LINE COMPONENTS.

5-2.1 Fill/Drain Line (FDL) Filter (F-2) (See Figure 5-1). Removal and replacement of (F-2) is as follows:

a. Ensure that all valves are closed except the vapor vent line shutoff valve (V-8). The dust cap should remain installed on the FDL coupling (13).

b. Open drain valve (12) completely and remove the stem/bonnet assembly.

c. Remove support brace (18) by tapping it towards the Tank.

d. Support the filter (11) to prevent movement and remove manifold from filter (11).

e. Support the elbow (16) to prevent it from turning and remove filter (11). Dispense of the filter through proper channels for cleaning.

f. Put anti-seize tape on the male threads of the elbow (16) and install a new filter making sure the arrow is pointed towards the Tank.

g. Put anti-seize tape on the male threads of manifold and install into filter (11). Ensure the globe valve body nipple is in position for installation.

h. Tap support brace (18) into position and secure.

CAUTION

Ensure that globe valves are in the full open position before reassembling the stem/bonnet assembly into the valve body. This will prevent damaging the components which seat the valve upon assembly.

i. Reassemble the stem/bonnet assembly into body of the FDL drain valve (12).

j. Leak test threaded joints.

5-2.2 Fill/Drain Line (FDL) Drain Valve (V-6) (See Figure 5-1). Removal and replacement of (V-6) is as follows:

a. Open (V-6) (12) and remove the stem/bonnet assmebly.

b. Disassemble stem/bonnet assembly as required (Refer to the Repair and Overhaul Instructions, T.O. 37C2-8-19-13).

c. Remove valve body (12) from manifold.

d. Put anit-seize tape on the male threads of manifold to which valve body (12) is mounted and install (12).

CAUTION

Make sure globe valves are in the full open position before reassembling the stem/bonnet assembly into the valve body. This will prevent damaging the components which seat the valve upon assembly.

e. If the stem/bonnet assembly was disassembled to effect repairs reassemble stem/bonnet assembly (Refer to T.O. 37C2-8-19-13).

f. Reassemble the stem/bonnet assembly into valve body (12).

g. Leak test the threaded joints.

5-2.3 Fill/Drain Line (FDL) Pressure Relief Valve (RV-2) (Figure 5-1). Removal and replacement of (RV-2) is as follows:

a. Support manifold tubing and remove (RV-2) (19) from manifold.

b. Put anti-seize ttape on the male threads of the relief valve. Support manifold tubing and install a new (RV-2) (19).

c. Leak test the threaded joint.

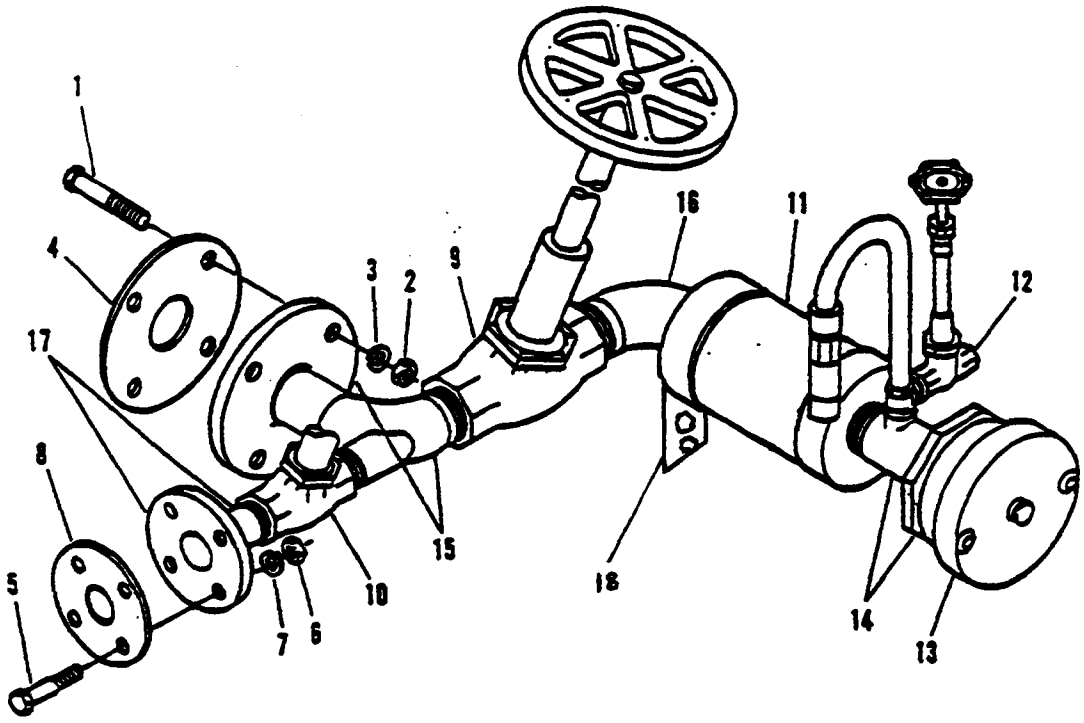
d. Test the valve's pressure opening after leak testing the threaded joints. For the pressure opening setting refer to Table 1-1.

5-2.4 Fill/Drain Line (FDL) LOX/LIN Coupling (See Figure 5-1). Removal and replacement of the FDL LOX/LIN coupling is as follows:

a. Remove LOX/LIN coupling (13) from the hex bushing (14).

b. Put anti-seize tape on the hex bushing (14) and install LOX/LIN coupling (13).

c. Leak test the threaded joints.



1.	BOLT	10.	PRESSURE BUILDING VALVE
2.	NUT	11.	FILTER
3.	WASHER	12.	DRAIN VALVE
4.	GASKET	13.	COUPLING
5.	BOLT	14.	NIPPLE
6.	NUT	15.	FLANGE
7.	WASHER	16.	ELBOW
8.	GASKET	17.	FLANGE
9.	FDL VALVE	18.	SUPPORT BRACE

Figure 5-1. Fill/Drain Line Component Removal and Replacement.

5-3 SERVICING LINE COMPONENTS.

5-3.1 Servicing Line (SL) Filter (F-1) (See Figure 5-2). Removal and replacement of (F-1) is as follows:

a. Ensure that all valves are closed except the vapor vent line shutoff valve (V-8).

b. Open drain valve (12) completely and remove the stem/bonnet assembly.

c. Support the filter (9) to prevent movement and remove manifold from filter (9).

d. Support the pipe nipple (6) to prevent movement and remove filter (9). Dispense of the filter through proper channels for cleaning.

e. Put anti-seize tape on the male threads of the pipe nipple (6) and install a filter making sure the arrow is pointed away from the tank.

f. Put anti-seize tape on the male threads of the manifold. Support filter (9) and install manifold into filter (9). Ensure that the globe valve body is in the correct position for installing drain lines.

CAUTION

Ensure that globe valves are in the full open position before reassembling the stem/bonnet assembly into the valve body. This will prevent damaging the components which seat the valve upon assembly.

g. Reassemble the stem/bonnet assembly into valve body (12) of the SL drain valve (12).

h. Leak test threaded joints.

5-3.2 Servicing Line (SL) Drain Valve (V-4) (See Figure 5-2). Removal and replacement of (V-4) is as follows:

a. Open (V-4) (10) and remove the stem/bonnet assembly.

b. Disassemble (10) as required (Refer to the Repair and Overhaul Instructions T.O. 37C2-8-19-13).

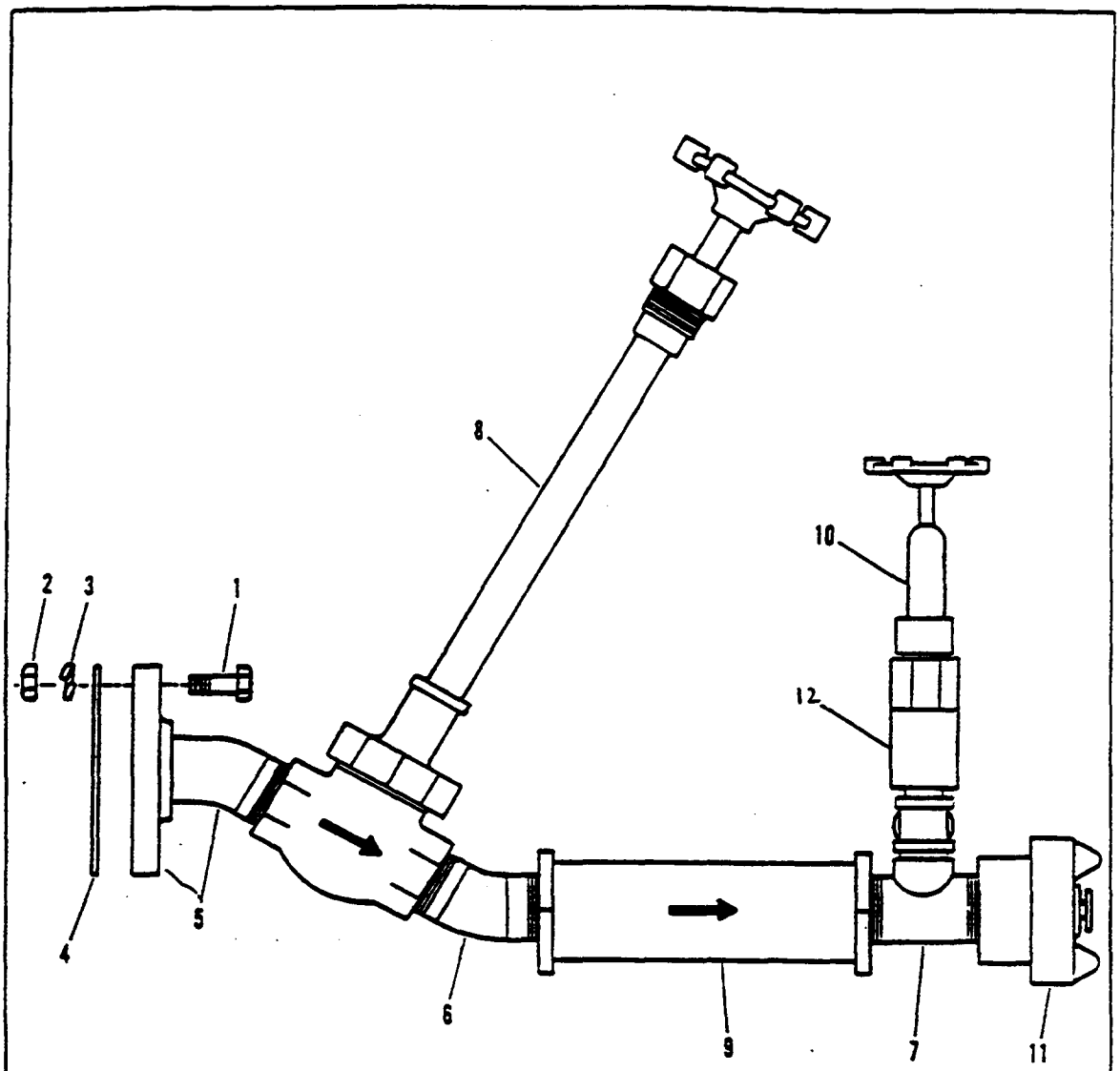
c. Remove valve body (10) from manifold.

d. Put anti-seize tape on the male threads of manifold to which valve body (10) is mounted and install (10).

CAUTION

Make sure globe valves are in the full open position before reassembling the stem/bonnet assembly into the valve body. This will prevent damaging the components which seat the valve upon assembly.

e. If the stem/bonnet assembly was disassembled to effect repairs reassemble (Refer to T.O. 37C2-8-19-13).



1.	BOLT	7.	TEE
2.	NUT	8.	SERVICE VALVE
3.	WASHER	9.	FILTER
4.	GASKET	10.	DRAIN VALVE
5.	FLANGE	11.	COUPLING
6.	NIPPLE	12.	RELIEF VALVE

Figure 5-2. Servicing Line Component Removal and Replacement.

f. Reassemble the stem/bonnet assembly into valve body (10).

g. Leak test the threaded joints.

5-3.3 Servicing Line (SL) Pressure Relief Valve (RV-1) (See Figure 5-2). Removal and replacement of (RV-1) is as follows:

a. Support manifold tubing and remove (RV-1) (12) from manifold.

b. Put anti-seize tape on the male threads of the relief valve. Support manifold tubing and install a new relief valve (RV-1) (12).

c. Leak test the threaded joints.

d. Test the valve's pressure opening after leak testing. For the pressure opening setting, refer to Table 1-1.

5-3.4 Servicing Line (SL) LOX/LIN Coupling (See Figure 5-2). Removal and replacement of the SL LOX/LIN coupling is as follows:

a. Disconnect the servicing hose and cover the end.

b. Remove LOX/LIN coupling (11) from the manifold.

c. Put anti-seize tape on the male threads of manifold and install LOX/LIN coupling (11).

d. Leak test the threaded joints.

5-4 CONTROL PANEL COMPONENTS.

5-4.1 Liquid Level Indicator (LL-1) (See Figure 5-3). Removal and replacement of (LL-1) is as follows:

a. Close the level indicator isolation valves (7). If the level indicator equalizer valve (6) is not already in the closed position then close (6).

b. Remove 90° connectors (11) at the female connectors.

c. Remove the nuts and lock washers which mount (LL-1) to the control panel.

d. Remove (LL-1) (3) from panel (1). Information on indicator cleaning procedures can be found in T.O. 37C11-1-1 (Refer to Table 1-2). The local Precision Management Equipment Laboratory (PMEL) is responsible for the indicator calibration. Consult with the cognizant PMEL on forwarding an indicator for calibration.

e. Remove the indicator male connectors (10).

f. Put anti-seize tape on the NPT ends of (10) and install (10) into the replacement indicator (3).

g. Install (3) into panel (1) and install lockwashers and nuts.

CAUTION

Do not pinch or bend tubing for indicators as this will result in restrictive product flow providing an inaccurate indicator reading.

h. Install 90° connectors (11).

i. Open isolation valves (7).

j. Leak test the threaded joints.

5-4.2 Level Indicator Equalizer Valve (V-12) (See Figure 5-3). Removal and replacement of (V-12) is as follows:

a. Close valves (7).

b. Remove 90° connectors (11 & 12).

c. Remove knob, packing nut, andel nut from valve (6).

d. Remove tees (5) and male connectors (10).

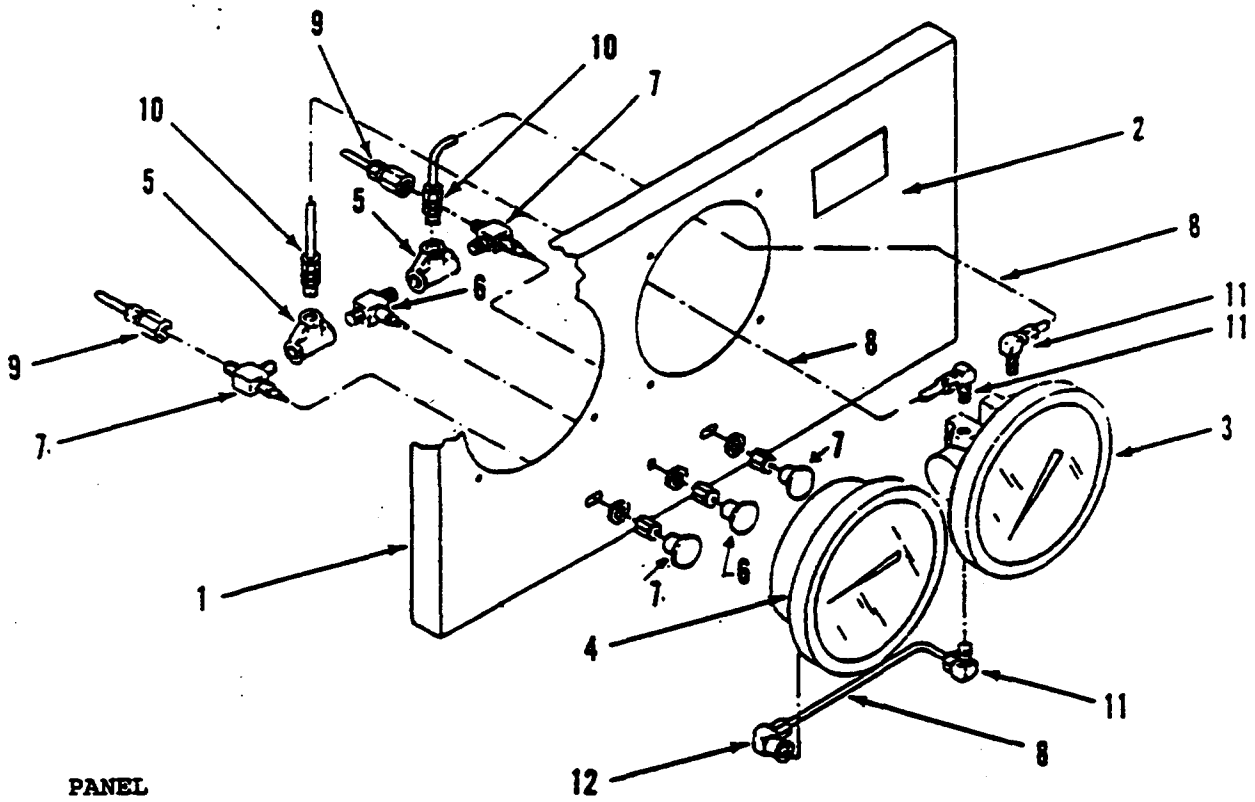
e. Put anti-seize tape on the NPT end of tees (5) and male connectors (10) and install into valve (6).

f. Install (6) in panel (1) and install panel nut, packing nut, and knob.

g. Install 90° connectors (11 & 12).

h. Open isolation valves (7).

i. Leak test the threaded joints.



1.	PANEL	7.	ISOLATION VALVE
2.	NAME PLATE	8.	TUBE, 1/4 IN. OD
3.	LIQUID LEVEL GAUGE	9.	STR. CONNECTOR, 1/4 IN. OD x 1/4 FPT (2)
4.	PRESSURE GAUGE	10.	STR. CONNECTOR, 1/4 IN. OD x 1/4 MPT (2)
5.	PIPE TEE, 1/4 IN. IPS (2)	11.	90° CONNECTOR, 1/4 IN. OD x 1/4 IN. MPT (3)
6.	EQUALIZER VALVE	12.	90° CONNECTOR, 1/4 IN. OD x 1/4 IN. FPT (3)

Figure 5-3. Control Panel Component Removal and Replacement.

5-5 VACUUM SYSTEM MAINTENANCE.

5-5.1 Tank Efficiency. The efficiency of the Tank depends on the vacuum in the annular space between the inner and outer shells. The vacuum may be lost by leaks, gas diffusion, or contamination. As it is impossible to maintain a perfect vacuum, some loss of the vacuum level may be expected as time passes. It is important to maintain records of the vacuum level of every Tank. A slow deterioration of vacuum as shown in the records will indicate normal loss with passage of time. To correct the loss of vacuum a simple evacuation (pump-out) is required instead of extensive repairs.

5-5.2 Evidence of Vacuum Loss. Outward indications of vacuum loss on the Tank are as follows:

a. A visible and abnormal amount of vapor escaping from the vapor vent line.

b. Severe weight loss while product is in idle storage.

c. High pressure in the inner shell whenever the vapor vent valve (V-8) (Figure 4-1) is closed. This will cause a constant relieving of the pressure relief valve (RV-3).

d. A cold, sweating outer shell.

e. Failure of a regular efficiency test.

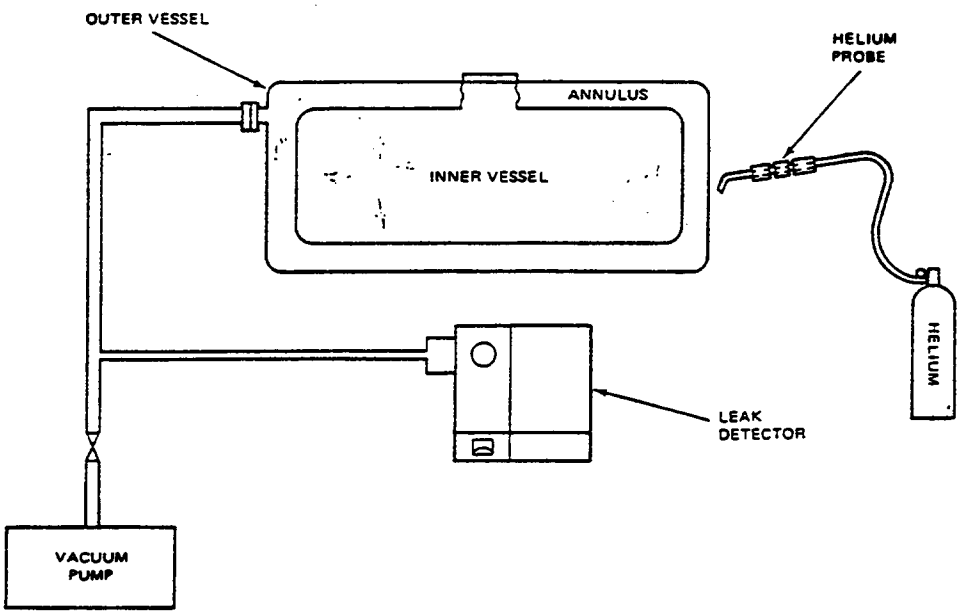


Figure 5-4. Annular Space Efficiency Test.

5-5.3 Repair Procedures. Determination of the cause of the loss may be extremely difficult. The tools and equipment for detailed leak detection are not available at the base level. Every attempt must be made to find the cause of the leak as this will determine which agency will be required to make the repairs. (Losses due to leaks or contamination are beyond the capabilities of base level repair).

a. When the repair requirements have been determined, depot assistance will be requested accordding to T.O. 00-25-107.

b. The request for depot assistance will include a description of all deficiencies of the Tank and a detailed repair cost estimate reported on AFTO Form 375. Instructions for preparing the AFTO Form 375 are contained within T.O. 35-1-24.

5-5.4 Vacuum Efficiency Test Procedure (See Figure 5-4). The use of the Dual Efficiency Meter is recommended, if available, in lieu of the portable vacuum gauge for determining the efficiency of the Tank vacuum. The vacuum gauge is used in the procedures as follows:

NOTE

For basic procedures for the Vacuum Gauge or Dual Efficiency Meter refer to Table 1-2.

a. Attach a portable thermocouple (vacuum) gauge (Refer to Table 2-1) receptacle to the vacuum sensor as shown in Figure 5-4.

b. Open the vacuum indicator shutoff valve (V-2) and allow the system to stabilize for two (2) minutes before proceeding.

c. Switch the thermocouple gauge to ON and read the gauge.

NOTE

The annulus vacuum in a cold Tank should be less than 10 microns. If the indication is greater than 35 microns the Tank must be evacuated (Refer to T.O. 37C2-8-19-13).

d. After the reading has been completed and recorded, close V-2 and set the thermocouple gauge switch to OFF.

CAUTION

To avoid vacuum loss make sure V-2 is closed tightly at all times except when taking a reading with a vacuum gauge.

e. Disconnect the thermocouple gauge receptacle from the vacuum sensor.

5-6. PURGING.

5-6.1 Purge. Purging is a process of forcing heated air through the drained tank, causing residual LOX/LIN and any contaminants which entered the tank to be converted to a gaseous state and be dispelled from the tank. Contaminants, such as moisture and carbon dioxide may be present in a solidified state at the cold LOX/LIN temperatures. These contaminants tend to settle or float in the tank so that the concentration increases with tank usage. When the

percentage of contaminants reaches an undesirable level, as determined by laboratory tests, or in case severe contamination, by odor testing, the tank must be drained, cleaned and purged as necessary.

5-6.2 Frequency. Liquid oxygen/ nitrogen storage tanks shall be drained and purges whenever the impurities exceed the use limits established in TOs 42B6-1-1 or 42B7-3-1-1, respectively. These TOs specifiy that whenever contamination is suspected, a sample of LOX/LIN product shall be sent to a designated laboratory to be tested for contaminants. The Liquid Oxygen/ Nitrogen Sampler Model FSC2001 or equivalent is required for this purpose. Analysis of the results of the test shall be used by the Base Fuels Officer to determine if purging is required. When contamination is authenticated, the source tank will be purged to ensure complete disposal of contaminants.

NOTE

All necessary repairs needed by the tank or cart should be accomplished when empty. Certain repairs require purging before and after the repairs are accomplished. Annular space evacuation (vacuum pumping) should be accomplished during the purging process. If it is not feasible to purge and pump at the same time, then the vacuum pumping should be accomplished after the purge, while the inner tank is still hot.

5-6.3 Procedures. Purging procedures will be accomplished according to the following steps:

a. Ensure storage tank has been drained prior to purging, if not, reference draining procedures in Section II.

b. Open vent valve, all other valves are closed.

WARNING

Ensure tank plumbing and filters are at ambient temperature before removal of any components.

c. Remove filters and disconnect tubing to pressure gauge and liquid level gauge, if applicable.

NOTE

The GSU-62/M purging unit or equivalent is required to purge LOX/LIN tanks.

d. Position GSU-62/M purging unit next to tank service line. Connect purging unit to source of 220/440-Volt, 3 phase, 60 cycle AC power outlet.

e. Connect necessary purge unit adapter to tank service line.

f. Connect purge unit discharge hose to tank service line, and attach temperature gauge to vent line outlet.

g. Open service line valve.

CAUTION

Do not allow the temperature of the air exiting the tank to rise above ($220^{o}F$) to prevent possible damage to the tank.

h. Start and operate purging unit following instructions given in T.O. 36G2-3-1. Continue to operate unit and monitor temperature gauge at vent line outlet, until the temperature of (220°F) is attained. The temperature of (220°F) can be maintained at the outlet by cycling the purge unit heater switch OFF and ON as necessary.

WARNING

All metal tubing and valves on the tank will become HOT. Contact with hot plumbing will result in burns.

i. Alternately open and close all other valves to assure hot air flow through all plumbing lines.

NOTE

The 220° F tank outlet temperature is the preferred temperature at which a tank should be purged. However, if conditions do not permit attainment of that temperature, the technician will reach the highest temperature possible and then continue purging for that period of time as stated in Table 5-1.

j. Operate purging unit at the maximum attainable temperature at the fill/drain line outlet for the time specified in Table 5-1.

Table 5-1. Purging Requirements

Maximum Temperature Attained	Purging Time (Hours)
220	4
210	6
200	8
190	12
180	16
170	24
160	32
150	48
140	64

k. When purging time is completed, turn OFF purge unit heater swtich. Continue air flow into inner tank until vent line outlet temperature gauge has cooled to (150°F) temperature. This will prevent cooling gases from later causing a vacuum to occur in the inner tnak and drawing atmospheric air and moisture into the inner tank if a valve is opened.

l. Close all valves, turn off and disconnect purge unit service hose and adpaters from tank and reposition purge unit away from the area.

m. Reconnect all tubing to instruments and install cleaned filters.

WARNING

To minimize thermal shock to the inner tank after purging, a 24 hour waiting period should be initiated to allow the inner tank to cool before service. This waiting period will be adhered to if operational requirement permit. Upon initial servicing of the tank, regardless of whether the tank was allowed to cool or not, the servicing pressure should not exceed 10 psig. This action will help lengthen the service life of the tank.

n. Fill tank in accordance with Section IV, paragraph 4-5.

5-7. TANK CONVERSION.

5-7.1 Purpose. The intention of this section is to give instructions for the conversion of liquid oxygen storage tanks to liquid nitrogen. The conversion of the tank from one product to another (LOX to LIN) shall be accomplished using the following instructions:

a. The affected parts in the conversion of the tank are the ordnance couplings, liquid level gauge, decals, and tank data plate. The replacement parts for the conversion of the tank will be listed in the Illustrated Parts Breakdown with a usable code of "A" for liquid oxygen and "B" for liquid nitrogen. Items listed in the IPB which do not have usable on codes are common to both configurations of the tank.

NOTE

Obtain all component parts necessary to accomplish the tank conversion, in advance, to avoid unnecessary delays in the conversion process.

b. Drain and purge the tank in accordance with the procedures listed in paragraph 5-6 prior to the actual conversion process to remove all product and any contaminants which may be present in the tank. Ensure that ground areas onto which liquid oxygen will be discharged are free from all hydrocarbons (oils, grease, lumber, wood, macadam, grass, etc.) These substances are not compatible with liquid oxygen and spontaneous combustion and/or explosion may result. Observe all safety procedures including the donning of protective equipment to prevent bodily contact with liquid oxygen and nitrogen, or with temperatures. REF. T.O. 00-25-172. During the purging operation all metal tubing, valves, couplings, and associated hardware, will become very HOT, contact with plumbing and skin will result in burns. Ensure plumbing and associated parts are ambient temperature before removal of any components.

NOTE

All necessary repairs, corrosion control, repainting, etc., needed by the tank should be accomplished when empty. Many repairs require purging before and after the repairs are accomplished. Annular space evacuation (vacuum pumping) should be accomplished during the purging process. If it is not feasible to purge and pump simultaneously, the the vacuum pumping should be accomplished after purge, while the

inner tank is still hot. This process will remove moisture which could be trapped in the annular space.

c. Remove couplings from the FILL/DRAIN line and SERVICE line assemblies.

d. Replace the couplings with those respective to product to which the tank is being converted.

e. Liquid oxygen decals will be removed and replaced with liquid nitrogen decals. These decals will be located in the same location as those removed.

f. Tank identification data plate will be removed. The data plate will be stamped, using 1/4 inch stencil, with the product, new part number, new national stock number, and related tank data in the appropriate place on identification data plate, and installed in the same location as the original plate.

NOTE

Notification of the conversion of all tanks shall be reported to the item manager in order to obtain new part number and national stock number.

NOTE

Insure appropriate data is recorded on the new data plate for the tank to be converted. The original serial number will be maintained from the old data plate.

g. The conversion of liquid nitrogen requires the liquid level gauge be recalibrated, modified, or replaced.

NOTE

Differential pressure type quantity indicators shall be recalibrated if required for liquid nitrogen service.

h. Fill the tank; check for leaks and proper operation. If no leaks or malfunctions are detected, the tank may be placed into service.

Table 5-2. Troubleshooting Procedures.

Trouble	Probable Cause	Remedy
a. Low flow rate through service hose.	Low Tank pressure.	Raise Tank to 55 psig.
	Clogged filter (F-1).	Remove and replace filter.
	Service valve (V-3) is partially closed.	Open valve fully. Also see g.
	Ice or contaminated product in ports, valves, or hose.	Check for and dispose of ice or contaminated product.
	Fill valve on the receiving tank is partially closed.	Open fill valve on the receiving tank.
b. Low flow rate through fill/ drain hose.	Clogged filter (F-2).	Remove and replace filter.
	Fill/drain valve (V-5) partially closed.	Open valve fully. Also see g.
	Supply valve on the supply tank is partially closed.	Open supply valve on the supply tank.
	Vapor vent valve (V-8) closed.	Open valve.
c. Liquid level gauge oscillates: FULL-EMPTY.	Leak in gauge line from Tank to gauge or an obstruction in the line.	Check for leaks in gauge line. Repair or remove obstructions as necessary.
d. Liquid level gauge consistently indicates high or low.	One of the valves at Tank is closed.	Check valves for proper positions.
	Gauge equalizer valve (V-12) in the balance position.	Set equalizer valve to the READ (closed) position.
	Gauge needle bent, stuck, or loose.	Tap gauge slightly. Inspect needle for bends. Repair or replace as necessary.

Table 5-2. Troubleshooting Procedures - Continued.

Trouble	Probable Cause	Remedy
d. (Cont'd) Liquid level gauge consistently indicates high or low.	Gauge damaged, out of adjustment or calibration.	Replace. Return to depot for calibration.
	Leaking gauge line or valve.	Inspect for leaks and repair as appropriate. Also see g.
e. Liquid Level or Pressure Gauge not operating.	Ice or foreign material clogging lines or bellows.	Disconnect line. Clean or thaw as necessary.
f. Frozen valve.	Moisture in stem packing.	Thaw and dry valve with hot, dry, oil-free, nitrogen gas. Tighten packing nut.
g. Frost on top of valve stem extending to the top.	Loose packing gland nut on valve stem.	Tighten packing gland nut.
h. Valve leaking vapor or liquid.	Foreign material or ice on valve seat.	Drain Tank. Disassemble valve and replace seat.
	Valve seat worn, broken or missing.	
i. Valve fails to pass product or gas.	Defective valve.	Inspect valve. Open and close it several times to check operation. Refer to T.O. 37C2-8-19-13, for disassembly, repair, and replacement procedures.
j. Tank will not build or maintain pressure with the pressure buildup valve (V-7) open.	Line to pressure buildup coil clogged.	Clear obstruction from line.
	Faulty pressure buildup valve.	See f and i.
	Relief valve leaking, frozen open, or opening too soon.	See f and h.

Table 5-2. Troubleshooting Procedures - Continued.

Trouble	Probable Cause	Remedy
j. (Cont'd) Tank will not build or maintain pressure with the pressure buildup valve (V-7) open.	Rupture disc has burst.	Replace rupture disc. Refer to T.O. 37C2-8-19-13.
	Low liquid level.	Fill Tank.
	Leaks to atmosphere.	Locate leaks. Repair if authorized.
k. Excessive Tank pressure.	Malfunction of pressure gauge resulting in faulty indication.	Check pressure gauge. Replace if necessary.
	Over-filling of Tank.	Drain excess product.
	Low liquid level with the Tank idle and vapor vent valve (V-8) closed.	Fill Tank.
	Pressure buildup valve (V-7) open or leaking.	Check valve for proper closing or leaks.
l. Loss of annulus vacuum.	Normal deterioration of vacuum.	Check vacuum level. Evacuate annulus.
	Leaks to atmosphere.	Check for leaks at rupture disc, outer tank, where piping enters tanks, and vacuum seal-off valve.
	Leaks at thermocouple or vacuum gauge valve.	Make sure that valve is closed and threaded connections are sealed. Replace components if necessary. Evacuate per T.O. 37C2-8-19-13.
m. Failure to attain vacuum during evacuation.	Incorrect reading of vacuum gauge.	Read gauge again or open vacuum indicator shutoff valve.
	Leaks in vacuum pump hose, or equipment.	Locate and repair leaks.

Table 5-2. Troubleshooting Procedures - Continued.

Trouble	Probable Cause	Remedy
m. (Cont'd) Failure to attain vacuum during evacuation.	Defective gauge.	Replace gauge with one of known accuracy.
	Undetected leak in Tank.	Locate and repair.
	Defective pump.	Repair pump with one of known performance.
	Moisture in pump lubricant.	Drain and replace lubriicant.
	Moisture in pump.	Open pump ballast valve.

SECTION VI

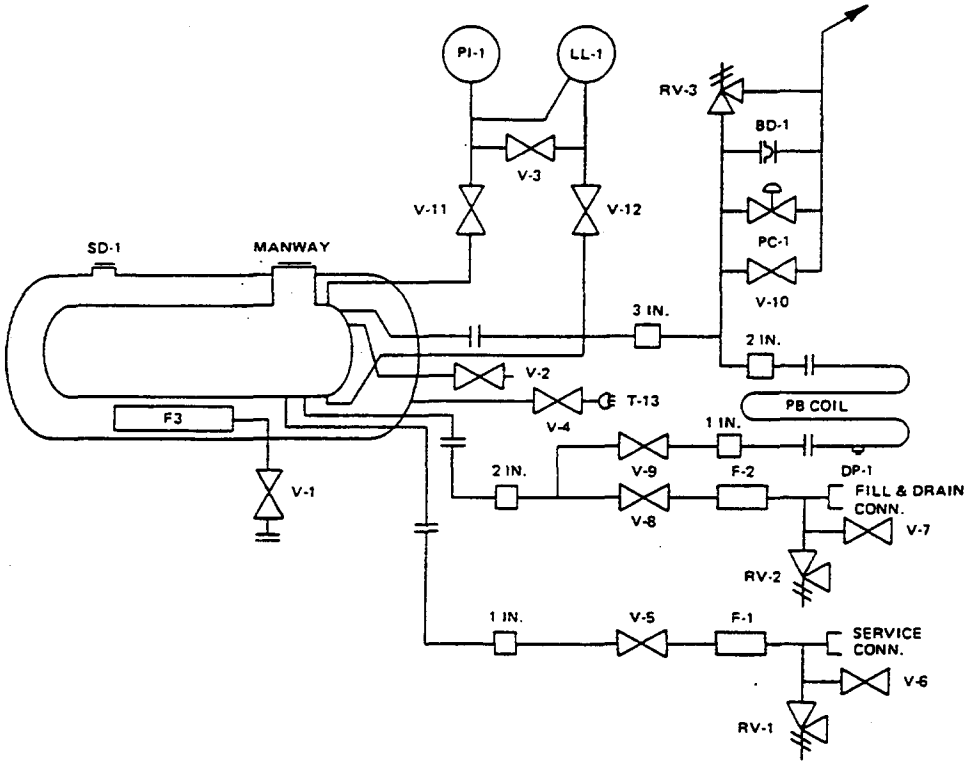
DIAGRAMS

6-1 FLOW SCHEMATIC DIAGRAM.

6-1.1 Scope. A Flow Schematic Diagram (See Figure 6-1) is included to provide maintenance technicians with a better understanding of the design and function of each component on the Tank.

6-1.2 The diagram will assist maintenance technicians for refernce purposes during troubleshooting and maintenance work.

6-1.3 A single diagram covers all of the cryogenic components used on the Tank.



V-1	VALVE - TANK EVACUATION
V-2	VALVE - FULL TRYCOCK
V-3	BALANCE VALVE
V-4	VALVE - VACUUM GAUGE PROTECTIVE
V-5	VALVE - SERVICE
V-6	VALVE - SERVICE LINE BLEED
V-7	VALVE - FILL & DRAIN LINE BLEED
V-8	VALVE - MAIN FILL & DRAIN
V-9	VALVE - PRESS BUILD-UP COIL
V-10	VALVE - TANK VENT
V-11	VALVE - ISOLATION LOW PRESSURE
V-12	VALVE - ISOLATION HIGH PRESSURE
T-13	TUBE - THERMOCOUPLE
BD-1	BURSTING DISC-TANK
F-1	FILTER-SERVICE LINE (25 GPM)
F-2	FILTER-FILL & DRAIN LINE (100 GPM)
F-3	FILTER-TANK VACUUM LINE
LL-1	LIQUID LEVEL INDICATOR-TANK
PI-1	PRESSURE INDICATOR-TANK
RV-1	RELIEF VALVE-SERVICE LINE
RV-2	RELIEF VALVE-FILL & DRAIN LINE
RV-3	RELIEF VALVE-TANK
PC-1	PRESSURE CONTROL VALVE
SD-1	SAFETY DISC TANK ANNULAR SPACE
DP-1	DRAIN PLUG

Figure 6-1. Tank Flow Schematic Diagram.

SECTION VII

ILLUSTRATED PARTS BREAKDOWN

7-1 ILLUSTRATED PARTS BREAKDOWN.

7-1.1 Scope. Refer to T.O. 37C2-8-19-14 (Illustrated Parts Breakdown) for a complete listing of parts for the Tank.

SECTION VIII

DIFFERENCE DATA SHEETS

8-1 DIFFERENCE DATA SHEETS.

8-1.1 Scope. No difference data sheets have been issued for this Tank.